

UNITED STATES MARINE CORPS
Logistics Operations School
Marine Corps Combat Service Support Schools
Training Command
PSC Box 20041
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LVSM 7211

STUDENT OUTLINE

MAINTAIN THE LVS HYDRAULIC STEERING SYSTEM

LEARNING OBJECTIVES

1. Terminal Learning Objective: Given an LVS, TM 2320-20/12A, TM 2320-34/13A, tools, and equipment, perform second echelon maintenance on the LVS hydraulic steering system, per the references. (3521.13.21)
2. Enabling Learning Objectives:
 - a. Given an LVS, TM 2320-20/12A, TM 2320-34/13A, tools, and equipment, inspect the hydraulic steering system components for serviceability, per the references. (3521.13.21f)
 - b. Given TM 2320-20/12A, TM 2320-34/13A, and partial statements pertaining to the LVS hydraulic steering system, complete the partial statements to describe the procedures used to diagnose a malfunctioning hydraulic steering system, per the references. (3521.13.21g)
 - c. Given an LVS, TM 2320-20/12A, TM 2320-34/13A, tools, and equipment, test the hydraulic steering system, per the references. (3521.13.21h)
 - d. Given an LVS, TM 2320-20/12A, TM 2320-34/13A, tools, and equipment, repair the hydraulic steering system, per the references. (3521.13.21i)
 - e. Given an LVS, TM 2320-20/12A, TM 2320-34/13A, tools, and equipment, adjust the hydraulic steering system, per the references. (3521.13.21j)

OUTLINE

1. IDENTIFICATION, LOCATION, AND FUNCTION OF THE COMPONENTS EMPLOYED IN THE MK48 HYDRAULIC STEERING SYSTEM

- a. Hydraulic Reservoir. The hydraulic reservoir is a holding tank that contains the hydraulic oil required for the LVS hydraulic system. It has a

holding capacity of 95 quarts and also houses the hydraulic oil filter. The reservoir is mounted on top of the right fender.

b. Hydraulic Oil Filter. The hydraulic oil filter is a six-micron filter that removes impurities from the oil before the hydraulic oil returns to the hydraulic reservoir. The filter is mounted on top of the hydraulic reservoir.

c. Tandem Hydraulic Pump. The tandem hydraulic pump is two gear type pumps joined together. Both sections of the pump are supplied with hydraulic oil through one inlet port (blue). The pump has two individual outlet ports, a low and high output. The hydraulic pump is located at the front of the vehicle above the wet air tank.

(1) Hydraulic oil from the low output side (red) of the pump is sent to the priority flow valve at the rate of 6 gallons per minute at low engine idle and 24 gallons per minute at a high idle.

(2) Hydraulic oil from the high output side (orange) of the tandem hydraulic pump is sent to the demand valve at a rate of 14 gallons per minute at low idle and 49 gallons per minute at a high idle.

d. Priority Flow Valve. The priority flow valve divides the hydraulic oil between the steering gear and the demand valve. During steering, hydraulic oil is pumped to the steering gear at a rate of 2.9 gallons per minute. The priority flow valve always directs enough hydraulic oil for steering and any excess oil will be directed to the demand valve.

e. Steering Gear Relief Valve. The steering gear relief valve limits the hydraulic pressure at the steering gear to 1750 pounds per square inch. When the hydraulic pressure exceeds 1750 pounds per square inch, the relief valve opens and allows oil to flow back to the hydraulic reservoir (yellow). The steering gear relief valve is positioned by the left front crossmember.

f. Steering Gear. The steering gear utilizes hydraulic pressure to assist in steering of the MK48. In the event of hydraulic system failure, the steering gear can still be operated mechanically to control the vehicle. The steering gear is located on the left side, secured to the frame behind the vehicle cab.

g. Demand Valve. The demand valve receives hydraulic oil under pressure from the high output side of the hydraulic pump and from the priority flow valve. The demand valve is a variable flow control valve that divides the hydraulic oil between the auxiliary selector valve and the cooling fan motor. The auxiliary selector valve will receive a steady flow of hydraulic oil

while the rate of oil flow to the fan motor will depend on engine speed. The demand valve is located below the hydraulic pump.

h. Fan Control Valve. The fan control valve is used to control the flow of hydraulic oil to either the fan motor or back to the hydraulic reservoir.

i. Hydraulic Fan Motor. The hydraulic fan motor is a double-gear type motor that rotates the cooling fan. The rotation of the fan blades pulls air through the cooling radiator and the hydraulic oil cooler. The hydraulic fan motor is located directly under the radiator.

j. Auxiliary Hydraulic Steering Selector Valve. The auxiliary hydraulic selector valve is used to direct hydraulic oil to the auxiliary hydraulics or to the steering system. When the selector valve is pushed in, the hydraulic oil is diverted to the steering system. When the selector valve is pulled out, oil is directed to the rear module's hydraulic system for crane or winch operation. The hydraulic steering selector valve is located on the right fender, behind the hydraulic reservoir.

k. Yaw Directional/Steering Relief Valve. The yaw directional/steering relief valve is electrically operated and controlled by the parking brake switch and the neutral safety switch. When the transmission is in neutral and the parking brake is set, the yaw directional/steering relief valve directs the hydraulic oil to the hydraulic reservoir. During vehicle steering operation, the hydraulic oil is directed to the yaw control valve.

l. Accumulator. The accumulator is used to absorb pressure surges or spikes before they can effect the operation of the hydraulic system. The accumulator also helps smooth out yaw steering. The accumulator is mounted on the left, rear side of the engine.

(1) The accumulator has two separate chambers with a flexible rubber bladder separating the two. One chamber is filled with hydraulic oil and connected to the steering hydraulic system. The other chamber is charged with nitrogen gas.

(2) During pressure surges, hydraulic oil surges inside the accumulator and tries to compress the rubber bladder against the nitrogen gas.

(3) After the pressure surge, the nitrogen gas forces the bladder and oil out. This is how the accumulator absorbs the energy of a pressure surge.

m. Yaw Control Valve. The yaw control valve is mechanically controlled by the bellcrank and the spring fuse link. The valve is used to signal the

motion control valve when the MK48 is making a right or left hand turn. The yaw control valve also signals the motion control valve when turning has stopped. The yaw control valve is mounted on the left side of the vehicle, connected to the bellcrank.

n. Motion Control Valve

(1) The motion control valve prevents the movement of the yaw cylinders when the steering system is in the neutral position. This prevents road wander at the articulation joint.

(2) The motion control valve also directs the hydraulic oil to the proper end of the yaw cylinders when a turn is being made.

(3) The motion control valve is located at the rear of the vehicle, directly above the transfer case.

o. Yaw Cylinder. There are two yaw cylinders on the vehicle that steer the rear module. Both cylinders receive hydraulic oil under pressure from the motion control valve. The yaw cylinders are double-acting cylinders that will extend or retract.

p. Hydraulic Oil Cooler. The hydraulic oil cooler is mounted on top of the coolant radiator. The hydraulic oil cooler is used to minimize excessive heat build up in the hydraulic oil system. This prolongs the life of the hydraulic oil and the hydraulic system components.

2. PRINCIPLES OF OPERATION FOR THE MK48 HYDRAULIC STEERING SYSTEM

a. The Tandem Hydraulic Pump has Two Separate Outlet Ports. The low output side (red) of the pump supplies hydraulic oil to the priority flow valve. The high output side (orange) supplies hydraulic oil to the demand valve. Oil to the pump is gravity fed or free flowing (blue) from the hydraulic reservoir.

(1) Low Output Side.

(a) The priority flow valve divides the flow of oil from the low output side of the pump to the steering gear and to the demand valve.

(b) The MK48 steering system provides full-time hydraulic assisted steering. During vehicle operation, a constant flow of oil travels through the steering gear (purple and yellow). When the steering wheel is turned, a piston and rack gear inside the steering gear housing moves, which rotates the steering output shaft. The relief valve plungers in the steering

gear will unload high pressure oil when the pitman arm is turned against the pitman arm stops. Oil is then directed back to the reservoir (yellow).

(2) High Output Side.

(a) Oil flow from the high output side (orange) of the hydraulic pump is directed to the demand valve. The demand valve also receives excess oil not required by the steering gear from the priority flow valve (red).

(b) The demand valve is a variable flow control valve that supplies oil (orange/red) to the fan control valve and auxiliary selector valve.

(c) The auxiliary selector valve has priority and will receive most of the hydraulic oil from the demand valve. Any excess oil will be routed to the fan control valve. The amount of oil pumped to the fan control valve depends upon the operating use and the engine speed of the MK48.

(d) The fan control valve is used to control oil flow to the fan motor. A temperature sending unit mounted on the left thermostat housing senses engine coolant temperature for the fan control valve.

1 When the engine coolant temperature is below 180 degrees Fahrenheit, a solenoid at the fan control valve will route the oil to the hydraulic reservoir (yellow).

2 When the engine coolant temperature is above 180 degrees Fahrenheit, the solenoid routes the oil to the hydraulic fan motor (violet). The fan control valve incorporates a pressure relief valve to protect the fan circuit. If pressures in the fan circuit reach 1550 pounds per square inch, the relief valve opens and the oil is routed back to the hydraulic reservoir (yellow).

(e) The hydraulic fan motor is a double-gear hydraulic motor that rotates the cooling fan. As the hydraulic fan motor rotates, the cooling fan pulls air through the radiator, the hydraulic oil cooler, and the transmission oil cooler, which are mounted above the cooling fan. Oil from the hydraulic fan motor returns to the hydraulic reservoir through the fan control valve (yellow).

(f) The auxiliary selector valve directs the oil to the auxiliary hydraulics or to the yaw steering.

1 While in the auxiliary hydraulics position, hydraulic oil is sent to the rear module for crane or winch operation (light green).

2 In the steering position, hydraulic oil is directed to the yaw control valve for yaw steering (green).

(g) The main relief valve is also incorporated in the auxiliary selector valve. The main relief valve protects the entire hydraulic system. If the pressure in the hydraulic system reaches 3,250 pounds per square inch, the relief valve will open and direct the oil to the hydraulic reservoir (yellow).

(h) As the vehicle turns, the yaw control valve is positioned by the bellcrank. A spool valve inside the yaw control valve will then direct hydraulic oil to the right or left steering circuit of the motion control valve (green).

(i) The motion control valve will direct the hydraulic oil to the piston end of one yaw cylinder, and the rod end of the opposite yaw cylinder, when the vehicle is turned.

1 When the vehicle is turned to the left, the motion control valve sends oil to the piston end of the right yaw cylinder (green). This forces the right yaw cylinder to extend. As the yaw cylinder extends, hydraulic oil in the rod end returns to the motion control valve (green/yellow).

2 Simultaneously, the motion control valve is sending oil to the rod end of the left yaw cylinder (green). This forces the left yaw cylinder to retract. Hydraulic oil in the piston end of the left yaw cylinder is returned to the motion control valve (green/yellow). This oil returning back to the motion control valve is sent back to the reservoir (yellow).

3 When the vehicle is turned to the right, the motion control valve sends oil to the opposite ends of the yaw cylinders.

4 The motion control valve also prevents the movement of the yaw cylinders when the steering circuit is in the neutral position, which prevents road wander. Two relief valves are incorporated in the motion control valve to protect both the left and right side of the yaw steering circuit.

b. All Hydraulic Oil in the MK48 Hydraulic System Passes Through an Oil Cooler before Returning to the Hydraulic Reservoir (Pink and Yellow). The oil cooler cools the hydraulic oil instead of engine coolant. The hydraulic oil cooler is mounted above the cooling fan. When the oil travels through the oil cooler it flows through many separate tubes that have cooling fins

attached to them. It is in the core that heat in the hydraulic oil is released to the atmosphere.

c. Hydraulic Oil is Filtered with a 6 Micron, Paper Element-Type Filter. A micron is a measurement to determine the degree of filtration. One micron is approximately 39 millionths of an inch. Any contaminants in the hydraulic oil larger than 6 microns will be filtered.

3. MAINTENANCE RESPONSIBILITIES RELATIVE TO THE MK48 HYDRAULIC STEERING SYSTEM

a. The organizational automotive mechanic, MOS 3521, at second echelon is responsible for replacing the following MK48 hydraulic system components.

- (1) auxiliary selector valve,
- (2) yaw control valve,
- (3) hydraulic oil cooler, filter, lines, and fittings,
- (4) yaw cylinders, and
- (5) hydraulic cylinders.

b. The second echelon mechanic is also responsible for servicing the complete hydraulic system, including the hydraulic reservoir.

c. The organizational automotive mechanic, MOS 3521, at third echelon is responsible for performing all of the previously mentioned tasks and replacing the following components:

- (1) priority flow valve,
- (2) flow control valve,
- (3) yaw relief valve,
- (4) fan control valve,
- (5) motion control valve,
- (6) demand valve,
- (7) selector relief valve,
- (8) fan drive motor, and

(9) hydraulic pump.

d. The third echelon mechanic is also responsible for adjusting the priority flow valve and accumulator and testing the hydraulic system.

4. REPAIR OF HYDRAULIC HOSES, TUBING, AND FITTINGS

a. Inspection of the Hydraulic Hoses, Tubing, and Fittings

(1) Visually inspect all hydraulic hoses for cracks or splitting, pin hole leaks, signs of rubbing, heat, or twisting. Check hoses for leaks or fraying where the hose and fittings are connected. This area is where most hose damage occurs.

(2) Make sure all hoses are routed properly and clamped correctly. A pinched hose will leak or create high pressure in the hydraulic system. Avoid sharp bends or loops.

(3) Inspect all fittings for leaks or cracks. Leakage is the most common failure of fittings. Check the fittings for damaged O-rings, stripped threads, or improper assembly.

b. Replacement of Hydraulic Hoses, Tubing, and Fittings

(1) Prior to the removal of any fittings or hoses, make sure that the vacuum pump kit is installed and in operation.

(2) Before removing any hydraulic hoses or tubing, note their routing and the location of all hold down clamps and nylon ties.

(3) Remove all necessary hold down clamps and nylon ties to free the hoses or tubing. Wipe all fittings clean before disconnecting them. This helps keep dirt out of the hydraulic system.

(4) To disconnect the fittings, use two Bonney wrenches. Bonney wrenches are special tools used to remove hydraulic lines and fittings. Their construction, wide openings with short handles, makes the removal and replacement of the lines and fittings easier. Although these wrenches are not listed in the TM for this vehicle, they are available in the supply system and are used extensively on aircraft hydraulic systems. We have found they are also very useful for the LVS hydraulic system. Never use pliers or pipe wrenches; these items may damage the fittings. Use one Bonney wrench to hold the stationary fitting and one Bonney wrench to loosen the swivel nut on the hose or tube.

(5) After disconnecting, cap the stationary fittings and plug the hydraulic lines to prevent dirt or other contaminants from entering the hydraulic system. If removing more than one hose or tube, tag and number the hoses or tubing and their connection points for proper assembly. Damaged hoses should be discarded.

(6) Replacement hoses or tubing must be of the same pressure rating, diameter, length, and type as the original hose or tube.

(7) To install new hoses, route the replacement hoses the same as the originals. Remove the plugs from the fitting ends. If pipe sealant is used, make sure the pipe sealant is applied to the male threads only. Install the new hose and tighten the fittings until finger tight. Use wrenches to tighten the fittings until snug, do not overtighten. Install all hold down clamps and new nylon ties. Check for leaks after installation. If leakage occurs, tighten the fittings one extra flat.

5. SERVICING THE HYDRAULIC FILTER ASSEMBLY

a. Inspection of the Hydraulic Filter Assembly. The hydraulic filter housing should be checked for any leaks around the hose connections, cover, plugs, and pressure check valve. Look for any cracks, dents, or damage in the housing.

b. Testing the Filter Assembly with STE/ICE-R. After inspecting the filter housing, a pressure test should be performed to determine if the hydraulic oil and filter need replacing. As the hydraulic oil picks up contaminants, the filter slowly becomes plugged. This creates a pressure increase inside the filter housing. For this filter, pressures above 12 pounds per square inch indicate a need to change the hydraulic oil filter. STE/ICE-R is used to measure the pressure inside the filter housing. A pressure reading of 12 pounds per square inch or less indicates clean hydraulic oil and that the filter is not plugged. To test the filter with STE/ICE-R the following procedures are used.

(1) Perform VIM general checkout procedures as prescribed in the technical manual.

(2) Remove the plug from the filter housing and install the blue strip pressure transducer to the filter housing.

(3) Connect P1 of transducer cable W4 to either J2 or J3 on the VIM.

(4) Now, connect P2 of transducer cable W4 to the blue stripe pressure transducer.

(5) At this time, Test No. 50 will be dialed into the test select and an offset test performed by holding the test button down until CAL appears on the display. This will calibrate the VIM, transducer, and cable.

(6) Once CAL has appeared, release the test button and wait for a limit value. Limits should be between -150 to +150.

(7) Again, press and release the test button. A "0" reading on the display should appear. You are now ready to measure pressure.

(8) Start the engine to cycle the hydraulic oil and allow the hydraulic oil temperature to reach 130-140 degrees Fahrenheit (54-60 degrees Celsius).

(9) Once the hydraulic oil is at the proper temperature, increase engine speed to maximum and record the reading.

(a) If the pressure reading is 12 psi or less, the oil filter is clean and is operating correctly.

(b) If the pressure reading is more than 20 psi, the hydraulic oil is heavily contaminated and should be replaced along with the oil filter. The hydraulic oil should be replaced, before the oil filter. It may be necessary to replace the filter more than once.

(c) If the pressure reading is between 13 psi and 20 psi, replace the oil filter.

1 Now, increase the engine speed to maximum and record the reading.

2 If the oil pressure is still more than 12 psi, replace the oil filter and repeat the test until a reading of 12 psi or less is obtained.

3 As I said before, it may be necessary to replace the oil filter more than once to remove all the contaminants from the system.

(10) Now, disconnect the blue stripe pressure transducer from the filter housing and install the plug.

c. Removal of the Hydraulic Oil Filter Element

(1) First, loosen the capscrews in the top of the filter cover.

(2) The cover is under spring pressure and care must be taken. Turn the filter cover counterclockwise and remove it from the filter housing.

(3) Now, remove the seal ring, spring, and bypass manifold and then remove the filter and O-rings on each side of the filter. Discard the filter seal ring and O-rings.

d. Replacement of the Hydraulic Oil Filter Element

(1) First, install a new oil filter. Make sure the O-rings are seated in the new filter.

(2) Next, Install the bypass manifold, spring, and seal ring on top of the oil filter.

(3) Now, place the filter cover on the filter housing and push the filter cover down and turn it clockwise to latch it in place. Finally install the capscrews and tighten them securely.

6. INSPECTION OF THE HYDRAULIC PUMP

a. Inspection of the Supply Hose

(1) Remove the screws securing the diagnostic connector assembly (DCA) access panel. Pull the DCA panel out and let it hang to provide better access for inspection.

(2) Inspect the supply hose for any leaks or signs of damage. Check the split flange for leaks, loose capscrews, or damaged flange parts.

b. Inspection of the Hydraulic Pump Housing

(1) Inspect the hydraulic pump housing for any cracks or broken pieces.

(2) Also check the outlet ports for damaged or leaking split flanges and hoses.

(3) Now inspect the hydraulic pump mounting capscrews for looseness or damage.

7. SERVICING THE HYDRAULIC SYSTEM

a. Inspection of the Hydraulic Reservoir

(1) Visually inspect the hydraulic reservoir for any leaks or dents.

- (2) Check the filler neck for any leaks or damage.
- (3) Check the sight glass for cracks, leaks, or damage.

b. Changing the Hydraulic Oil

(1) A container capable of holding 95 quarts of hydraulic oil is required for this service. A large funnel may also be needed to divert the oil into the container.

(2) First, the drain plug must be removed from the bottom of the hydraulic reservoir and the hydraulic oil allowed to drain.

(3) Next, the filler cap should be removed from the filler neck.

(4) After all the hydraulic oil has drained, the drain plug should be reinstalled.

c. Flushing the Hydraulic System. Normally, the only time that the hydraulic system needs to be flushed is when a large amount of contaminants has been found within the system. This can be determined by the STE/ICE filter test that was covered earlier. Of course, this procedure will be used when it is time to perform the scheduled PMCS on the hydraulic system.

(1) To flush the hydraulic reservoir, the filter assembly must be removed.

(2) After the filter has been removed, remove the twelve nuts securing the access plate and filler neck to the reservoir. Now remove the access plate and gasket and discard the gasket.

(3) Next, remove the screws attaching the diagnostic connector panel and then remove the DCA panel. This will allow access for the removal of the hydraulic pump supply line.

(4) Now, the capscrews, lockwashers, two split flange halves, pump supply line, and O-ring should be removed from the hydraulic pump. A container should be placed under the supply line to catch any fluid in the line.

(5) The inside of the hydraulic reservoir should be wiped clean with clean, lint-free rags. Also clean out the filter housing.

(6) Using clean hydraulic oil, flush the oil in the reservoir down through the pump supply line. The reservoir should be flushed until all visible debris has been removed.

(7) With the reservoir cleaned, the pump supply line can be secured to the hydraulic pump with a new O-ring, two split flange halves, new lockwashers, and capscrews.

(8) After the supply line is connected to the pump, the diagnostic connector panel can be reinstalled.

(9) Next, the gasket and access plate with filler neck should be positioned on top of the reservoir and secured with new locknuts.

(10) Install a new hydraulic filter. A new filter should always be installed whenever the hydraulic system is flushed.

(11) The hydraulic reservoir should be filled with clean hydraulic oil to the level line on the oil level gage. Refer to the lubrication instructions for the correct type of oil.

(12) Finally, check for leaks around the supply line connection. If no leak is detected, start the engine and check for leaks when the system is operating.

8. IDENTIFICATION, PURPOSE AND PROCEDURES FOR USING HYDRAULIC SYSTEM TEST EQUIPMENT

a. Flow Meter. The HT-75 Model "B" is a 75 gallons per minute in-line hydraulic flow tester that is a compact, self contained, portable instrument for testing hydraulic systems in the shop or in the field.

(1) Pressure Control Valve. The pressure control valve regulates system pressure by restricting the flow to varying degrees to develop back pressure in the system. To increase the pressure, turn the control valve handle clockwise; to reduce the pressure, turn the control valve handle counterclockwise. The control valve will maintain the pressure setting during and after the change in flow.

NOTE: Before testing the system, open the pressure control valve all the way by turning the valve handle counterclockwise. Exercise care when operating the pressure control valve, the pressure should be increased slowly.

(2) Pressure Gauges. Pressure readings are taken from the high pressure and low pressure gauges on the flow block.

(a) High Pressure Gauge. The high pressure gauge is a 0-6000 psi gauge and is located to the left of the gauge block.

(b) Low Pressure Gauge. The low pressure gauge is a 0-600 psi gauge and is located to the right of the gauge block.

(c) As pressure is increased, the low pressure gauge will give readings up to 500 psi and then cut out, allowing higher pressure to be recorded on the 0-6000 psi gauge.

(3) Gauge Snubber Knob. A gauge snubber knob is located at the left corner of the gauge block. The snubber knob is turned clockwise at a low pressure setting to dampen the pulsation of the gauge needles.

NOTE: When the gauges are dampened, the reaction of the needles to pressure increases or decreases may take a few seconds. Sufficient time for needle reaction must be allowed. Maximum pressure must be worked up to through a series of moderate increases.

(4) Overload Protection Safety Disc. A safety disc located at the front of the flow tester protects the flow tester from extreme pressure. If the pressure exceeds 6093 psi, the disc will rupture, relieving oil and reducing pressure before damage can occur.

(5) On/Off Switch. The on/off switch is a push-pull type switch. Pull to switch the unit on; push to switch the unit off. When the unit is not in use, make certain the switch is in the off position.

(6) Fuse. The fuse protects the meter from incorrect hookup when using auxiliary power sources.

(7) Flow/RPM Switch. The flow/rpm switch is set in the flow position to obtain a flow reading on the meter and set in the rpm position when using the photo tachometer.

(8) Hi/Low Range Switch. The Hi/Low range switch is used to read gallons per minute flow at low and maximum pump output. The low range scale will read 3 to 15 gallons per minute flow and the high range scale will read 15 to 75 gallons per minute flow.

(9) Temperature Switch. The temperature switch is used to measure the temperature of the hydraulic fluid flowing through the flow meter. When the switch is depressed, the meter reading of the flow will be cancelled and the temperature mode will take over. Upon release of the switch, the meter will return to the flow position.

(10) Batteries. The unit is provided with three 9-volt, transistorized batteries that must be installed prior to operation. The

batteries are mounted in the battery compartment located on the under- side of the case.

(11) Auxiliary Power Jack. The auxiliary power jack is used in conjunction with an auxiliary power cord to allow the unit to draw power from 12 or 24 volt batteries for field use or when batteries for the unit are not available. An auxiliary power converter cord can also be used to operate the flow meter from any 120 volt, 60 cycle outlet.

(12) Meter. The meter gives flow and temperature readings depending on the switch mode used.

(13) Low-Battery Light. The low-battery light is provided to alert the operator that battery power is at a low point where erroneous readings will result. When the batteries run down, the light will come on, indicating low battery power.

(14) Inlet and Outlet Ports. The inlet and outlet ports are located in the manifold body and are designed to accept SAE straight "O" ring union adapters, 1 1/16 - 12 male thread by 3/4 NPSM female straight union. The inlet port is located on the left side of the manifold and the outlet port is located on the front of the unit. The flow tester is supplied with cover plugs on both inlet and outlet ports to protect the unit from damage or contamination. The ports should always be covered when the unit is not being used. Make certain all hoses are connected properly to the tester. The pressure hose from the pump or pressure line of the system must be connected to the tester inlet port. The return hose must be connected to the tester outlet port. If the hoses are connected improperly, the unit will give flow readings, but the pressure control valve will not work.

(15) Hose Connector. The hose connector is located on the front of the unit and surrounds the safety disc to act as a shield to minimize the scattering of oil should the safety disc rupture. To further alleviate oil problems, a 1 1/4" I.D. hose should be slipped onto the connector and clamped in place. The hose should be of sufficient length to direct oil flow back to the reservoir, or to a container.

(16) Calibration Jack. The calibration jack is used in conjunction with the calibrator, which is an accessory item for the flow meter. The flow meter does not need to be calibrated before each use, but the calibrator should be used at six month or one year intervals to check meter accuracy, or if erroneous readings are suspected. The flow meter needs to be recalibrated if it is repaired due to damage.

(17) Test Hose. The two test hoses that are used to connect the flow meter into the hydraulic lines are high pressure hoses that are adapted with

quick disconnect fittings. When a line is disconnected from a component, the line and component must be adapted with quick disconnect fittings to accommodate the flow meters hose quick disconnect fittings.

b. 0-5000 PSI Gauge. The 0-5000 psi gauge is used to test the system pressure at various points by connecting to the test ports within the system. The gauge has a flexible hose and a quick disconnect fitting attached to it. When the gauge is attached to a quick check fitting, oil from the hydraulic system flows into the gauge, thus hydraulic system pressure is obtained.

c. Vacuum Pump Kit. The vacuum pump kit is used to create a vacuum in the hydraulic oil reservoir so lines within the hydraulic system may be disconnected with minimum loss of hydraulic fluid. The vacuum pump kit is a Model #2217. The pump is designed to connect to the 12 volt side of the vehicle's batteries for power. A hose from the vacuum pump control valve is designed to fit the special hydraulic oil reservoir cap, which fits the hydraulic oil filler tube. When the pump is turned on, the vacuum pump control valve can be adjusted to create 18 inches of vacuum in the hydraulic oil reservoir. Lines and components can then be disconnected or removed with little or no loss of fluid.

9. TESTING AND ADJUSTMENT OF HYDRAULIC STEERING SYSTEM COMPONENTS

a. Testing and Adjusting the Auxiliary Selector Relief Valve. Testing and adjusting the auxiliary selector relief valve is a procedure that is normally performed when servicing the hydraulic system.

(1) Start the engine and check the low idle speed. Low idle must be set at 690 revolutions per minute. Higher settings will cause parts damage.

(2) Shut down the engine and disconnect the three couplers at the articulation joint. The engine must always be shut down before removing or installing hoses or test equipment.

(3) Install a 0-5,000 pounds per square inch pressure gage to test port 5 on the demand valve.

(4) Push the auxiliary selector valve in to the steering position.

(5) Start the engine and allow the hydraulic oil to warm up to operating temperature.

(6) When performing the test, do not hold the auxiliary hydraulic steering selector valve in the auxiliary hydraulics position for more than 15 to 20 seconds. While adjusting or testing, do not hold in the auxiliary hydraulic position if the pressure is above 3,250 pounds per square inch.

Serious damage will result to the hydraulic pump if the pressure rises above the recommended relief setting or is held in auxiliary hydraulics for a longer length of time than allowed.

(7) Position yourself so you can read the pressure gage. Have an assistant pull the auxiliary selector valve out to the auxiliary hydraulics position. Read the pressure gage. The pressure should be 3,150 - 3,250 pounds per square inch. If the pressure reading is above or below this range, the auxiliary selector relief valve must be adjusted.

(a) To adjust the pressure, position the auxiliary selector valve in the steering position and loosen the jam nut on the relief valve. Turn the set screw clockwise to increase the pressure or counterclockwise to decrease the pressure.

(b) Repeat the test and adjust the setscrew, as needed, until the pressure setting is within limits. Tighten the jam nut to lock the setscrew in position. Repeat the test to make sure the pressure setting has not changed.

(8) Shut down the engine before disconnecting any gages or connecting the hydraulic lines.

(9) Remove the pressure gage from the demand valve.

(10) Connect the three couplers at the articulation joint. It may be necessary to wait a few minutes to allow the pressure in the couplers to bleed off before they can be connected. If pressure is still present after several minutes, it may be necessary to loosen a line to bleed off pressure.

b. Testing and Adjusting the Priority Flow Valve. The testing and adjusting of the priority flow valve will be accomplished when checking the flow and pressure to the steering relief valve or a malfunction occurs where the vehicle steers hard in one or both directions.

(1) First, remove the cab access panel next to the transmission shifter and then place a container under the vehicle in the area where the hydraulic lines will be disconnected to catch any fluid that will drain from the lines.

(2) Next, ensure that the wheels are set in the straight ahead position.

(3) The vehicle engine will have to be operated to warm the hydraulic oil to at least 130-160 degrees Fahrenheit before checking flow. Once the oil has reached the desired temperature, shut down the engine.

(4) Prior to removing any hydraulic line, the vacuum pump must be connected and a vacuum created in the hydraulic reservoir.

(a) First, remove the reservoir filler cap and install the special hydraulic reservoir cap from the vacuum pump kit.

(b) Next, connect the electrical leads from the vacuum pump kit to one of the vehicle's batteries. Remember, the pump is 12-volts only.

(c) Now turn on the vacuum pump and adjust the control valve to create 18 to 25 inches of vacuum in the hydraulic oil reservoir. The vacuum pump kit gage will let you know what the control valve is adjusted to.

(5) Now disconnect hydraulic line 274 from the steering gear relief valve. Connect the flow meter in line with the steering gear relief valve and line 274. To do so:

(a) connect the inlet line of the flow meter to the steering relief valve opening,

(b) connect the outlet line of the flow meter to hydraulic line 274, and then

(c) fully open the pressure control valve on the flow meter by turning the knob counterclockwise.

(6) With the flow meter properly installed, shut off the vacuum pump and remove the special hydraulic reservoir cap from the hydraulic reservoir. Install the hydraulic reservoir cap.

(7) Now, loosen the jam nut on the priority flow valve and preset the adjusting screw by turning it fully in and then backing it out two and a half turns. Make sure that the adjusting screw is not over tightened, this may cause damage to the priority flow valve.

(8) Make sure that the steering wheel is not turned in either direction while the system is being tested or adjusted; movement of the steering wheel can cause damage to the hydraulic system components.

(9) Now, start the engine and increase to maximum engine speed.

(10) With the engine at maximum speed, close the control valve on the flow meter by turning the knob clockwise to increase to create a 1000 psi working pressure.

(11) Now check for 2.8-3.0 gpm flow.

(12) If the flow is not correct, turn the adjusting screw on the priority flow valve in to reduce flow, or out to increase flow. Never turn the adjusting screw in fully while the engine is running. This will dead head the hydraulic pump, causing hydraulic pump or line failure.

(13) Once the correct flow is obtained, tighten the jam nut on the priority flow valve without disturbing the setting of the adjusting screw.

(14) Now turn the control knob on the flow meter counterclockwise to decrease pressure; and shut off the engine.

(15) Connect the vacuum pump as was previously instructed and turn it on and allow it to run until 18 to 25 inches of vacuum appears on the pressure gage.

(16) Disconnect the flow meter from the steering relief valve and hydraulic line 274, and reconnect hydraulic line 274 to the steering relief valve.

(17) Now, shut off the vacuum pump and disconnect the vacuum pump from the hydraulic reservoir and the vehicle battery.

(18) Finally, install the filler cap on the hydraulic reservoir and replace the access panel.

11. INTRODUCTION TO THE LVS HYDRAULIC STEERING SYSTEM SIMULATION TRAINING PANEL

a. As you can see, the panel face has an illustration of an LVS front power unit with all steering system components illustrated inside the MK48 silhouette. The components you will be required to inspect and test are called-out. That is so they could be illustrated larger than they could have been inside the silhouette.

b. Before we talk anymore about called-out components, let's look at some other illustrated components that are not called-out. Look right between the vehicle's wheels at about 5 o'clock. You'll see an illustration of the yaw control valve and an arrow leading to a component switch for the yaw control valve. Now, going in a clockwise direction you will see four more switches for the accumulator, steering gear, tandem hydraulic pump, and the fan motor. Remember when you press any component switch, it will light up. In addition, certain mode switches will also light up. The mode switches are telling you what action you can take. For example, the REPAIR/REPLACE switch may be lit as well as the INSPECT switch. Whatever action you want to take, you simply select the action you want from the available options.

c. Now, back to the called-out components. We'll start just below the yaw control valve and go clockwise. The component switch next to the called-out components work exactly like those we just finished discussing.

(1) The fan control valve has three component switches associated with it; one is for the valve itself, one for line #881, and one for the fan solenoid. On or near the fan control valve you will also see four jacks. The two on line #881 are used for hydraulic test and the two on the solenoid are for electrical testing.

(2) The next called-out component to the left is the steering gear relief valve. It has four component switches. The switches are for lines 274 and 725, for adjustment of the valve, and one for the complete valve. There are also five jacks associated with this valve and its plumbing. Notice that one of these jacks is at test port #3, you use the 0-5000 psi pressure gage at the test ports.

(3) To the left of the steering gear relief valve you see the priority flow valve. It has five component switches. There is one switch for each of the three lines that are associated with the valve, one for simulating a pressure adjustment and one for the complete valve that you would use if you intended to inspect the valve or replace it. There are also four jacks on this valve for simulated hydraulic testing.

(4) Moving again to the left, you see the demand valve. It has four switches, three are for lines 876A, 875, and 879; the other component switch is for the complete valve. There are also nine jacks on or adjacent to this valve. Three jacks are for test ports and the remainder are for lines. Remember, the 0-5000 psi gage is used for testing at the test ports.

(5) Above and to the right of the demand valve, the hydraulic selector valve is illustrated. In the center of the valve is a push/pull switch. That switch is used to select either auxiliary hydraulics or steering. There are also two component switches. One is used to adjust pressure and the other selects the complete valve for accomplishment of whatever functions are indicated as being available by way of lighted mode switches.

(6) Moving to the left and up, you see an illustration of the hydraulic reservoir; it has two switches associated with it. One switch lets you check hydraulic fluid level and the other lets you inspect the reservoir.

(7) To the right and above the illustrated hydraulic reservoir, there is an illustration of the vehicle's directional relief valve. It has four component switches; two for lines, one for the valve's solenoid and one for the complete valve. There are also six jacks associated with this valve.

Four jacks are used in conjunction with hydraulic testing and the other two for electrical testing.

(8) Moving to the other side of the panel, still at the top, you can see the motion control valve. It has three component switches and six jacks. You can see that two jacks are for the valve's test ports and the other four jacks are associated with the valve's plumbing.

(9) Below and to the right of the motion control valve, you can see a jack for test port #6. Again, you use the 0-5000 psi pressure gage at this test port.

(10) The remaining called-out components are the two yaw cylinders. The switches and jacks associated with the yaw cylinder are the same as on other components with minor exceptions. The plugs at the end of each hydraulic cylinder on the side are used in conjunction with the 0-5000 psi test gage. The component switches there are used to remove the plugs prior to inserting the adapter that is required and the 0-5000 psi test gage.

d. At the bottom of the panel, in the center you will see an illustration of the vehicle's dash panel. On the right side of the panel you see the simulated shift lever with a two-position switch, neutral and drive. Below the shift lever you can see the engine's OFF/ON/START switch and a toggle switch that is used to stop the engine. Those items work just like the ones on the actual vehicle. Moving left you can see the engine tachometer and hydraulic fluid temperature gages. Those gages are active and function according to panel condition (normal or malfunctioning). The other gages are just illustrations and are obviously not active. Moving to the left again, you can see you have a knob for simulated left and right steering, a two position throttle, and a push/pull switch for the parking brake.

12. SIMULATED TEST EQUIPMENT PROVIDED WITH THE LVS HYDRAULIC STEERING SYSTEM PANEL

a. The first item of test equipment we'll discuss is the 0-5000 psi pressure gage. To use this gage you simply connect a test lead that simulates the gage's hose to the jack illustrated with the gage and plug the other end into the test jack at the component being tested. The gage itself is a direct reading gage.

b. Moving over to the right of the illustrated dash panel you can see a simulated flow meter. It works exactly like the flow meters you have in your shops. Since you have already used the flow meter during practical application type training, there is no need to discuss how it is used again.

c. The remaining test instrument is a digital multimeter. It works just like all other digital multimeters you have been exposed to. You simply connect the leads, power it up, and select the appropriate function switches for the type electrical test you intend to do to use this meter. To the left of the multimeter, you will see a common ground jack that can be used during electrical testing.

13. USE OF MODE, ACTION, AND STATUS SWITCHES

a. The mode switches are used in conjunction with component switches. For example, when to press the component switch for the left yaw cylinder, two mode switches will light up; REPAIR/REPLACE and INSPECT. The lighted mode switches give you your options as to what you can do, you simply press the one you want. When you again press the component switch and the mode switch it will reverse the action, if appropriate. The first press of REMOVE/INSTALL, if that was an option, would remove the item and the second would install it. In this case if you had selected to inspect, a video would appear on the monitor showing you the yaw cylinder. Since we do not have a fault inserted, it would appear in a normal state. Remember, the mode switches are always used in conjunction with a component switch, never alone.

b. Action switches, that we will discuss now, are used alone. These switches can be used at any time; however, if you press one that would cause a hazardous condition or that represents an incorrect procedure, the system will detect that. Look at the five action switches now; what they are used for is pretty obvious.

c. Let's say you used an incorrect procedure. What will happen? That leads us into the status switches and the light. Notice the INCORRECT PROCEDURES status light, it's not a switch; however, when it lights, you will have to press the CHECK SYSTEM CONDITION switch to find out what to do so you can move on. The incorrect procedure you took will be recorded by the computer and the instructor will be alerted. Ultimately, the number of incorrect procedures you take will be used to determine if you have mastered diagnosis of steering system malfunctions.

14. TESTING THE LVS HYDRAULIC STEERING SYSTEM IN THE NORMAL CONDITION

a. During the next hour, I want all students to use the panel in the free play mode and become familiar with panel functioning. Each student at the station must use each of the items of test equipment on the panel for testing and also, each should exercise all the panel controls so you'll know how they work. Use your technical manual in conjunction with free-play testing. Remember, you will get all normal readings.

b. Commence free-play now, I'll advise you when your time is up. The assistant instructor assigned to your student station will be available at all times to help you if needed.

15. DIAGNOSIS OF THE ERO COMPLAINT "VEHICLE STEERS HARD IN BOTH DIRECTIONS"

a. Referring to the vehicle TM, you can see that the first thing we should do is to turn the ignition off if it is on, place the transmission in neutral, set the parking brake, and put the hydraulic selector valve in the steering position. All students must accomplish those steps now.

b. Now, I want you to press the action switch labeled "CHECK MECHANICAL SYSTEM." At this time you will get a video sequence indicating the oil type is normal and there are no leaks or damage to the system. This is a check that is described in the organizational maintenance manual. Get used to using both manuals while working this panel.

c. Now, we need to start the engine and attempt to yaw steer. The TM says it should not be possible to yaw steer with the vehicle transmission in neutral. Note that the video indicates that the vehicle yaw steered.

d. Next, the TM tells you to check for 24 volts at the directional relief valve. To do that we need to stop the engine and turn ignition switch off.

e. To conduct the electrical test, you need to disconnect the wiring at the directional relief valve. To do that press the component switch at the solenoid connector and the mode switch DISCONNECT/CONNECT. Note the visual of the disconnected wiring on the monitor.

f. Now, since we're going to check for voltage, you need to condition your multimeter. Select 200 volt range, select the volt function, push PEAK/HOLD to off and turn the power to multimeter on. With the multimeter set up go ahead and connect the leads to the multimeter. Connect the negative voltmeter lead to directional relief valve solenoid connector pin and the positive lead to the socket.

g. Turn the ignition switch on and read the multimeter. It is indicating zero voltage. We know now that the wiring must be bad because we should be reading battery voltage.

h. Now to effect the repair, push the component switch at the electrical connector for the directional relief valve solenoid and the REPAIR/REPLACE mode switch. With the repair accomplished, we need to connect the connector. Do that now by again pressing component switch and the DISCONNECT/CONNECT mode switch. Also, stow your test equipment.

i. To check the repair, you can simply press CONDUCT OPERATION CHECK. Since we did a good job, we get a video message that the steering system is normal. You could have started the engine again and learned that yaw steering was not possible with the transmission in neutral. That would have also told you the complaint was fixed.

j. To move to the next lesson you now press the status switch "LESSON COMPLETE." When you do that the video should inform you that lesson is complete and the "NEXT LESSON" light will come on. If you want to free-play the panel now, you would have to do so before you call for the next lesson. To move on, simply press "NEXT LESSON."

REFERENCES:

Instructor Utilization Handbook (Device 11H118)
TM 2320-20/12
TM 2320-34/13